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Atomic and molecular quantum gases in an optical lattice

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We report on recent progress in preparing and manipulating ultracold atomic and molecular ensembles in a 3D optical lattice. Starting from an atomic ^{87}Rb condensate which is adiabatically loaded into a 3D optical lattice we can control the state and dynamics of the gas on the quantum level with the help of static magnetic fields, radio-frequency and laser radiation and a Feshbach resonance. For example, we can produce a pure molecular ensemble of Rb_2 Feshbach molecules in the lattice [1] and can coherently transfer it to a more deeply molecular bound state via STIRAP [2] or radio-frequency transitions. Besides possible applications for investigating molecular collisions and producing ultracold molecules in the vibrational ground state, this can also be used for spectroscopic precision measurements of molecular levels. Besides studying chemically bound molecules, optical lattices also allow for forming a novel kind of stable bound state of two atoms which is based on repulsion rather than attraction between the particles [3]. We will explain how these lattice-induced repulsively bound atom pairs come about and discuss their interesting properties.

[1] G. Thalhammer et al., Phys. Rev. Lett. 96, 050402 (2006).
[2] K. Winkler, cond-mat/0611222
[3] K. Winkler et al., Nature 441, 853, (2006).